Volume 10, Issue 11, November – 2025 International Journal of Innovative Science and Research Technology
ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25nov1349

# IOT Based Solar Dryer for Agriculture Products

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Publication Date: 2025/12/04

**Abstract: This paper presents the design, implementation, and performance analysis of an IoT-enabled solar dryer for agricultural produce. The system integrates temperature and humidity sensors, a microcontroller, and a buck converter for voltage regulation. Real-time data monitoring and control are achieved via a web dashboard. Experimental results show significant improvements in drying efficiency and energy savings compared to traditional sun drying. "Blynk", a cloud-based IoT platform was used to develop remote monitoring system that enables constant monitoring of the temperature, humidity of products in the solar dryer. As a result, the effectiveness of upgrading traditional sun drying with IoT technology can help reduce the challenges and disadvantages that fish drying farmers have faced. The study, with correct drying monitoring criteria, could serve as a model for other food products that can be dried.**

***Keywords:*** *Solar Panel and Battery; Blynk IoT; Buck Converter; Low Cost Drying System; DHT11 Sensor Integration; High Efficient; Relay Control.*

**How to Cite:** Avinash Welankiwar; Achal Ninawe; Dhanashri Dukare; Ujwal D. Bahadure; Sagar M. Kale; Manish Tighare; Aniket Shende (2025). IOT Based Solar Dryer for Agriculture Products. *International Journal of Innovative Science and Research Technology*, 10(11), 2475-2481. https://doi.org/10.38124/ijisrt/25nov1349

## I. INTRODUCTION

Post-harvest losses in agriculture are a major concern, especially in tropical regions. Solar drying offers a sustainable solution, but conventional systems lack control and efficiency. This project introduces an IoT-based solar dryer that enhances drying performance through real-time monitoring and automated control of environmental parameters. In this drying system, electricity is saved through integration of solar and agriculture products will dry without loosing its texture.

This also ensure the hygiene which lacks in conventional method. This drying system comes with integration to iot software which provides the drying update which senses through sensor to user via user interface and also provide control of system. Experimental results demonstrate humidity and temperature effect during drying as well as significant improvements in drying time and energy utilization compared to conventional methods shown in the further section paper.

➢ *Here are Some Scholars Who Have Worked on Same Topic:*

- Mohrir & Prashanth (2025) developed a solar dehydration system with IoT and energy storage materials. Their setup used simple sensors and microcontrollers to maintain optimal drying conditions and log performance data.
- Lingayata et al. (2020) reviewed indirect solar dryers with enhancements like roughened solar collectors and heat storage. They emphasized the role of IoT in improving control and reducing drying time.
- Hyder et al. (2023) designed a modular solar dehydrator for fruits, integrating basic IoT features to monitor chamber conditions and improve drying uniformity.

➢ *Key Themes Include:*

- Automation: Using microcontrollers and sensors to monitor and control internal conditions (temperature and humidity) automatically, ensuring optimal drying parameters.
- Remote Monitoring: Implementing IoT platforms (like the Blynk app or ThingSpeak) and wireless connectivity to allow users to monitor the drying process and receive alerts from their smartphones or computers, reducing manual labor.
- Hybrid Systems: Incorporating auxiliary heat sources (e.g., electric bulbs) or thermal energy storage materials (e.g., phase change materials or PCMs) to enable continuous, 24/7 operation, overcoming the problem of intermittent sunlight.
- Performance Benefits: Research consistently shows that these intelligent systems lead to faster, more hygienic drying with higher-quality final products (better color, nutrient retention) compared to traditional sun drying.

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- Economic Viability: The use of free solar energy makes these systems cost-effective over time, offering a high return on investment for farmers by reducing post-harvest losses and producing value-added goods.

## II. SYSTEM ARCHITECTURE AND COMPONENTS

➢ *Components Description*

This section provides an overview of the electronic and mechanical components used in the project, detailing their function and role within the overall system.

➢ *ESP8266 Node MCU*

The ESP8266 Node MCU is an open-source development board that serves as the central controller and Wi-Fi module for the project. It is responsible for reading data from various sensors and sending it to a connected device, such as a smartphone. The board features a microcontroller with on-board processing and storage capabilities, as well as a micro-USB port for programming and power as shown in fig no.

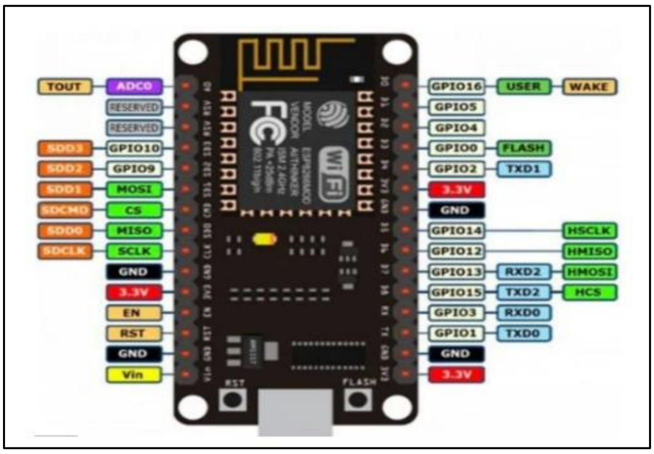


Fig 1 ESP8266 Node MCU

➢ *DHT11 Sensor*

This sensor measures the temperature and humidity inside the dryer chamber. It is a low-cost component that uses a capacitive humidity sensor and a thermistor to provide a calibrated digital output. The DHT11 is often used in home weather stations, environmental monitoring systems, and climate control projects.

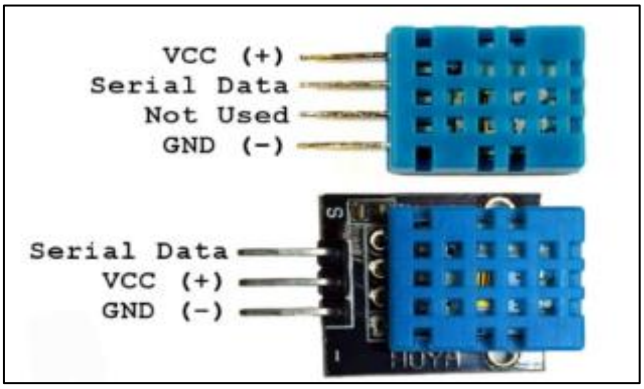


Fig 2 DHT11 Sensor

➢ *12V DC Fan*

These fans are used to circulate hot air to speed up the drying process and also to cool the solar panel.

Fig 3 12V DC Fan

➢ *DC Motor Speed Controller*

This component controls the speed of the DC fans to effectively manage the airflow within the system.

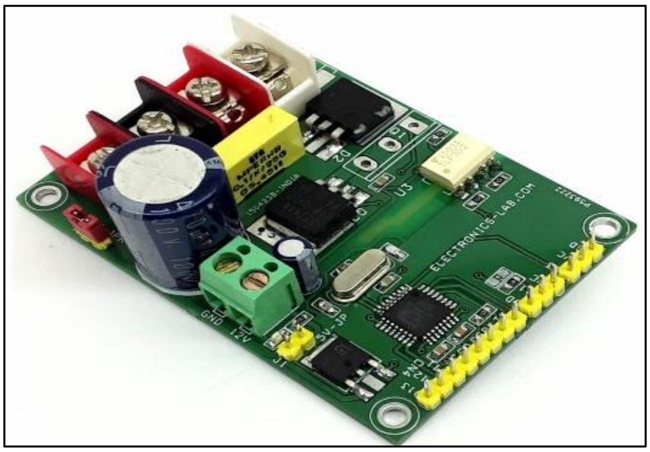


Fig 4 DC Motor Speed Controller

➢ *16x2 LCD Display*

The 16x2 LCD Display shows real-time temperature and humidity readings directly on the device, providing a local user interface.


Fig 5 16x2 LCD Display

➢ *Connecting Wires*

These wires are used to connect all the components, forming the complete circuit of the project.

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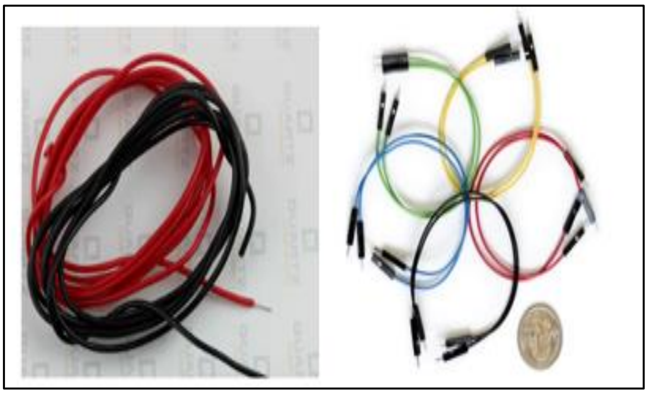

Fig 6 Connecting Wires

➢ *USB Cable*

A USB cable is used to program the NodeMCU and supply it with power during development and operation.

Fig 7 USB Cable

➢ *20W Solar Panel*

The 20W solar panel is a key component for energy generation, powering the entire system.

Fig 8 20W Solar Panel

➢ *Integrity of the Components*

- Power Supply: A solar panel generates power, which is stored in a battery. A relay module controls the flow of power to the rest of the system. A buck converter is used to regulate the voltage from the battery to a level suitable for the microcontroller.
- Microcontroller: An ESP8266 board serves as the central processing unit. It receives data from the DHT11 sensor and sends it to the BLYNK IoT App. It also sends control signals to the relay module and the LCD.
- Sensors and Display: The DHT11 sensor measures the temperature and humidity, and its data is sent to the ESP8266. An LCD is connected to the ESP8266 to display the readings.
- Motor Control: The ESP8266 sends a control signal to the relay module, which in turn powers the speed controller. The speed controller then regulates the power supplied to the fan, controlling its speed.
- Remote Monitoring: The ESP8266 is connected to the BLYNK IoT App, which allows for remote monitoring and control of the system.
- Power Management module: The system is designed for autonomous operation in rural or off-grid settings. Power is supplied by a photovoltaic (PV) solar panel, which charges a battery backup system during daylight hours. This ensures continuous operation of the MCU and critical sensors, even when thermal energy collection ceases. The power management module incorporates both a 12V DC supply for driving the high-power fans and exhaust blowers, and a regulated 5V DC supply necessary for the low-power electronics, including the ESP32 and the sensor array. The sizing of the solar panel and battery must account for the substantial energy required for drying.

## III. WORKING

➢ Working of the System: The system begins with the Start block, which is initiated when power is supplied through the solar panel and battery. The ESP8266 microcontroller starts executing the code, and all the required modules and sensors are initialized. In this initialization process, components such as the solar panel, battery, ESP8266 Wi-Fi module, DHT11 temperature and humidity sensor, LCD display, and fan are set up for operation. The system ensures that each component is properly powered and ready to communicate.

➢ After initialization, the program checks the status of the rocker switch, which serves as the main control for the system. If the rocker switch is OFF, the system goes into an idle or shutdown state, turning off. It remains in this state until the switch is turned ON. If the rocker switch is ON, the system proceeds to perform its main functions.

➢ Once the system is activated, it begins to read temperature and humidity data from the DHT11 sensor. The ESP8266 microcontroller collects the sensor readings and processes them for transmission. These values are then sent to the ESP8266 Wi-Fi module, which is responsible for connecting the system to the internet and communicating with the IoT platform.

➢ After obtaining the data, the ESP8266 transmits the temperature and humidity readings to the Blynk IoT platform, allowing real-time monitoring on a mobile application. This step enables remote users to view environmental parameters directly on their smartphones through the Blynk app interface.

➢ Simultaneously, the same data is displayed on the LCD module connected to the system. The LCD continuously shows updated readings of temperature and humidity, ensuring that the user can monitor values locally even

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25nov1349

without internet access. Additionally, based on temperature readings, a fan can be automatically controlled—for example, it may turn ON if the temperature exceeds a certain threshold and turn OFF when the temperature drops back to normal.

- Finally, the flowchart concludes with the End block, indicating that the system has completed one full operational cycle. However, in practice, the system continues to work in a continuous loop, repeatedly reading sensor data, updating the LCD, and transmitting data to the IoT platform as long as the power supply is available and the rocker switch remains ON.

## IV. OBSERVATION

Table 1 Temp & Humidity for Spinach

| Time | Temperature (°C) | Humidity (%) |
|---|---|---|
| 1:00 PM | 44.5 | 41 |
| 1:30 PM | 46.2 | 38 |
| 2:00 PM | 48 | 35 |
| 2:30 PM | 49.5 | 33 |
| 3:00 PM | 50.7 | 31 |
| 3:30 PM | 51.3 | 29 |
| 4:00 PM | 50.2 | 28 |
| 4:30 PM | 48.6 | 27 |
| 5:00 PM | 46.1 | 26 |
| 5:30 PM | 44 | 25 |

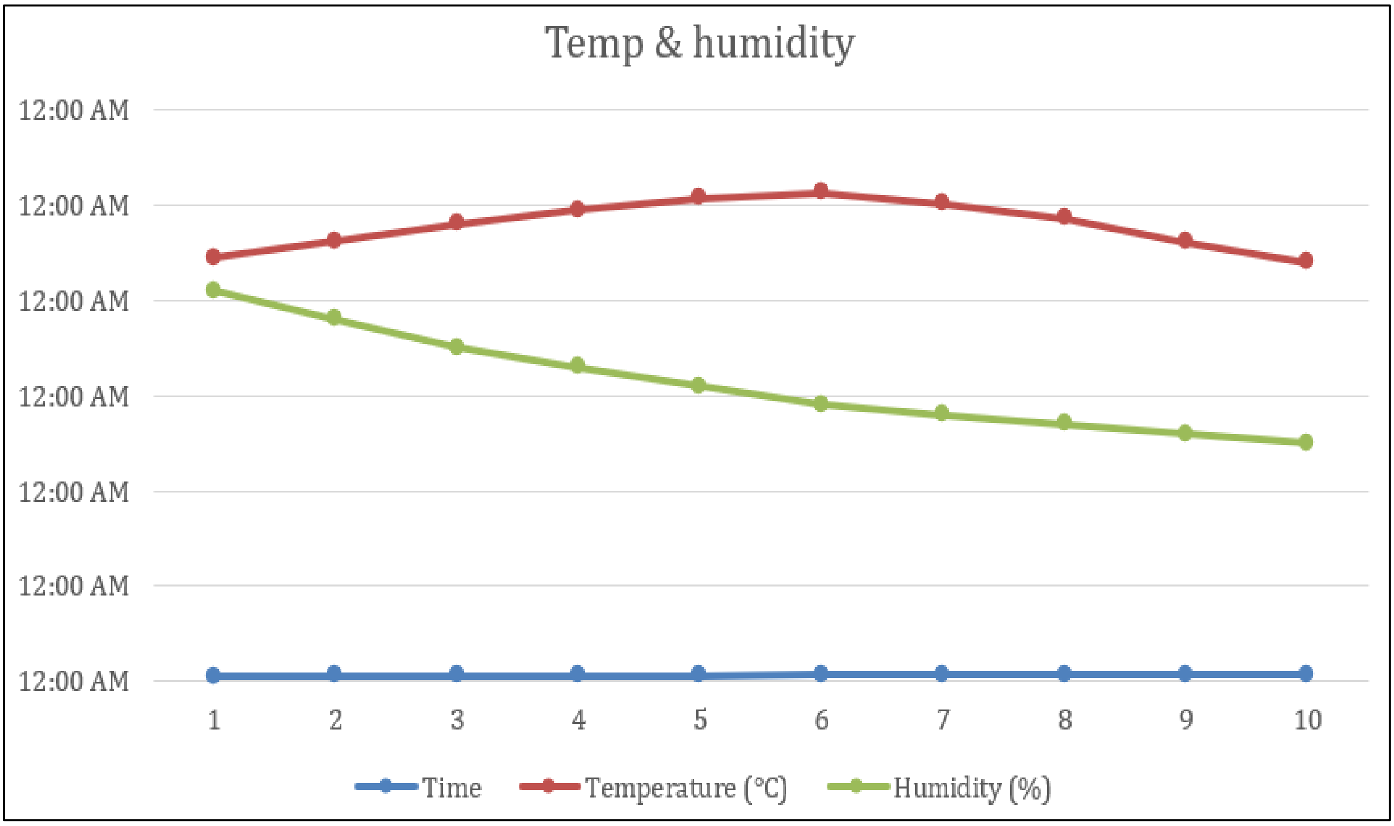

Fig 9 Temp & Humidity for Spinach

Table 2 Temp & Humidity for Sliced Potatoes and Cut Chillies

| TIME | TEMPERATURE | HUMIDITY |
|---|---|---|
| 7:30am | 35.2 °C | 55.50% |
| 8:00am | 37.6°C | 46.20% |
| 8:30am | 47.7 °C | 24.20% |
| 9:00am | 48.7 °C | 21.30% |
| 9:30am | 49.1°C | 19.00% |
| 10:00am | 50.0 °C | 17.00% |

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| | | |
|---|---|---|
| 10:30am | 51.02°C | 15.70% |
| 11:00am | 52.5 °C | 14.00% |
| 11:30am | 45.6°C | 24.70% |
| 12:00am | 43.5°C | 20.70% |
| 12:30am | 46.1°C | 24.10% |
| 1:00am | 44.2°C | 25.30% |
| 1:30am | 43.0°C | 27.30% |
| 2:00am | 43.8°C | 25.10% |
| 2:30am | 42.9°C | 26.80% |
| 3:00am | 49.0°C | 20.70% |
| 3:30am | 51.2°C | 18.00% |
| 4:00am | 48.9°C | 16.70% |
| 4:30am | 44.5°C | 10.70% |

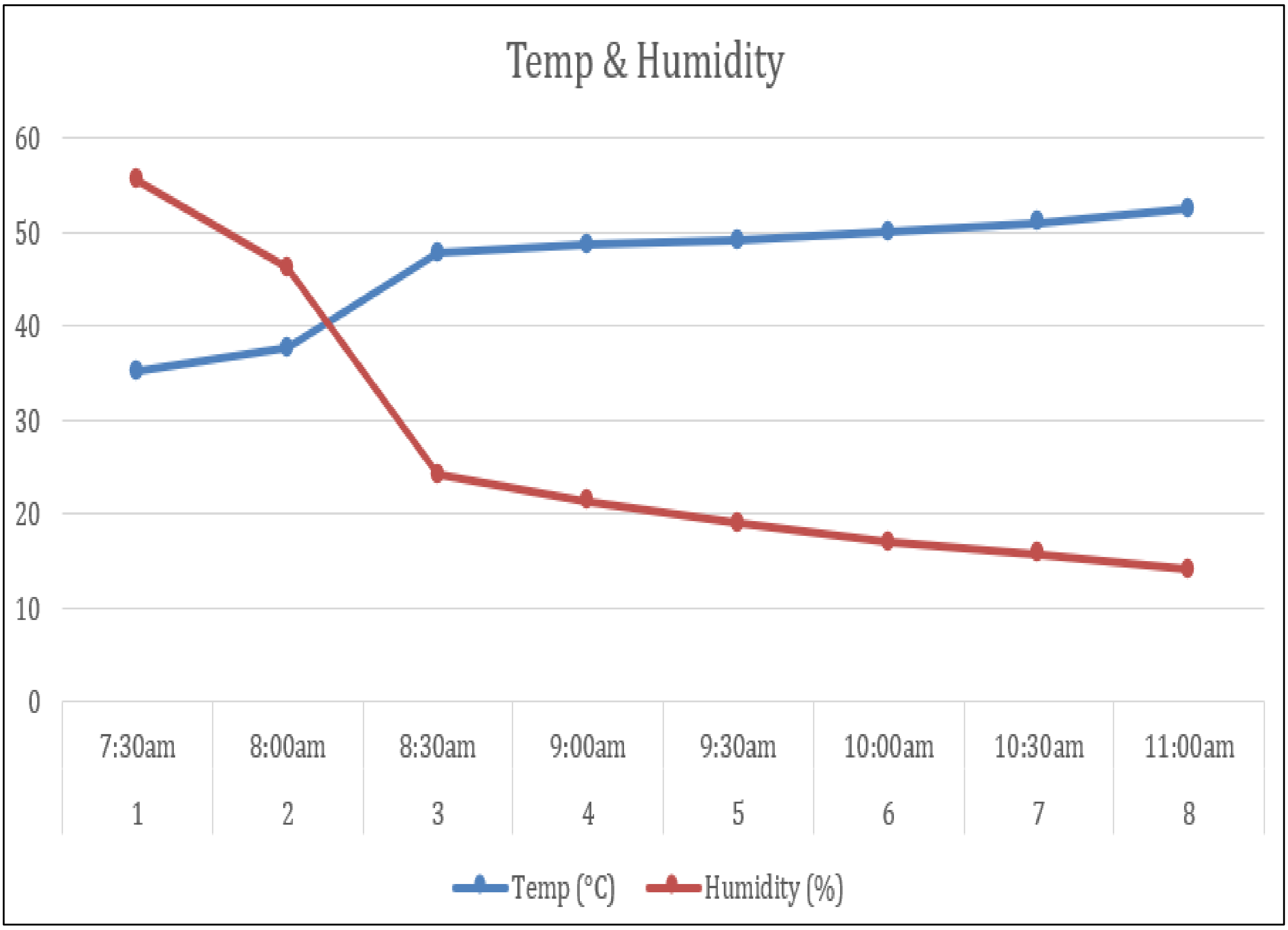


Fig 10 Temp & Humidity for Sliced Potatoes and Cut Chillies

Table 3 Temp Vs Humidity Graph for Sliced Potatoes and Cut Chilli

| Time | Temperature (°C) | Humidity (%) |
|---|---|---|
| 9:00am | 29.2 | 70.7 |
| 9:30am | 31.6 | 66.8 |
| 10:00am | 40.7 | 30.7 |
| 10:30am | 45.3 | 28.3 |
| 11:00am | 48 | 29.9 |
| 11:30am | 38.7 | 28.2 |
| 2:30pm | 39 | 27 |
| 3:00pm | 41.9 | 24.2 |
| 3:30pm | 44 | 22 |

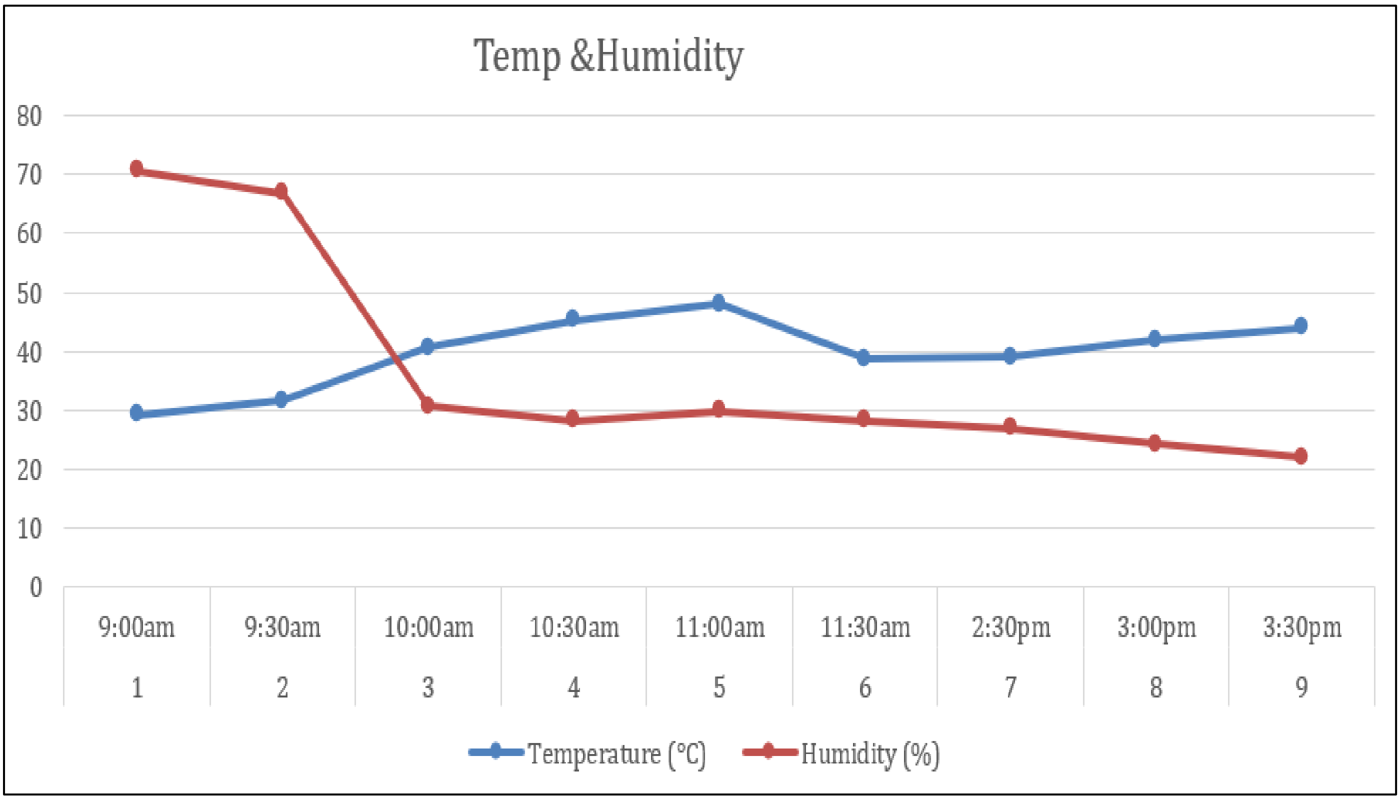


Fig 11 Temp Vs Humidity Graph for Sliced Potatoes and Cut Chilli

➢ *The Combined Data Indicate that Our Solar Dryer Chamber is Achieving Elevated Temperatures Well Above Ambient and Significantly Reducing Humidity.*

- There is a clear trend of temperature increasing during daytime hours (especially from late morning to early afternoon) and correspondingly relative humidity decreasing. On Day 1: 1:00 pm at 44.5 °C/41 % → 3:30 pm at ~51.3 °C/29 % as shown in
- On Day 2 the morning starts relatively cooler and higher humidity, then rapidly the temperature rises (to ~52.5 °C by 11:00) while humidity drops to ~14%.
- Day 3 shows a lower start temperature (~29.2 °C at 9:00) with higher humidity (~70.7 %), then temperature jumps by 10:00 to ~40.7 °C with humidity ~30.7%. This suggests perhaps a cloud break or direct sun heating from late morning causing sudden rise.
- The inverse relation (higher temp → lower humidity) is clearly evident.
- The maximum recorded temperatures around midday/afternoon reach ~50–52 °C and humidity falls to ~14–22% in some readings.
- Such high temperatures with low humidity are favorable for drying of agricultural products (as the dryer environment becomes more aggressive in removing moisture).

Table 4 The Combined Data Indicate that Our Solar Dryer Chamber is Achieving Elevated Temperatures Well Above Ambient and Significantly Reducing Humidity.

| **Parameter** | **Day 1 Range** | **Day 2 Range** | **Day 3 Range** |
|---|---|---|---|
| Temperature | 44 (Min) to 51.3 (Max) | 35.2 (Min) to 52.2 (Max) | 29.2 (Min) to 48 (Max) |
| Humidity | 41(Min) to 25 (Max) | 14 (Min) to 55.5(Max) | 22 (Min) to 70.7 (Max) |

## V. RESULT & DISCUSSION

As compared to traditional open sun-drying method, solar drying is more convenient. Since, the drying time here is significantly low.

Table 5 Performance Metrics: Solar Dryer vs. Traditional Drying.

| **Parameter** | **Solar Dryer** | **Traditional Open-Sun Drying** |
|---|---|---|
| Peak Temperature | High | Lower |
| Humidity | Very Low | Higher |
| Drying Time | Significantly Reduced | Longer |

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Table 6 Drying Time Comparison: Solar Dryer vs. Traditional Drying

| Vegetable | Preparation | Typical Traditional Open Sun Drying Time | IOT Enabled Solar Drying |
|---|---|---|---|
| Spinach Leaves | Whole or blanched leaves, spread in a thin layer | 1 to 2 days (approx. 15 hours of sun exposure) | 5 - 6 hours |
| Chili Peppers | chilies | 6 to 15+ days (48 to 120+ hours) | 4-5 days (Approx. 40 – 70 hours of sun) |
| Potato Slices | Thin slices | 1 to 4 days (approx.10 to 20 hours of sun exposure) | 8 - 13 hours (1-2 day of sun) |

## VI. CONCLUSION

Here's a more concise version of your context, preserving all key technical and functional highlights:

The IoT-Based Smart Solar Dryer System achieves elevated temperatures (~45–52 °C) and low humidity (~14–30%) during peak hours—ideal for drying agricultural products. The inverse relationship between temperature and humidity confirms effective operation, enhancing drying potential.

The system integrates an ESP32 microcontroller with temperature and humidity sensors for precise, continuous monitoring, preventing over-drying or spoilage and preserving produce quality. Real-time data access via the Blynk mobile app enables remote monitoring and timely interventions.

Powered by a solar panel and battery, the dryer is energy self-sufficient and eco-friendly. A smart-controlled exhaust fan enables forced convection, accelerating drying and reducing contamination risks.

This intelligent, cost-effective upgrade to traditional dryers supports sustainable post-harvest management, reduces losses, and boosts profitability—advancing the shift toward Smart Agriculture.

## ACKNOWLEDGMENT

We wish to express our profound gratitude to all those who provided invaluable support, guidance, and resources throughout the design, fabrication, and testing of the Solar Dehydrator Project.

I would like to express my deepest gratitude to my project guide, Prof. Avinash Welankiwar for their invaluable guidance, constant encouragement and for solving problems which faces throughout this project. Their expertise and dedication were crucial to the completion of this work.

I also extend my thanks to the Head of Department, Dr. Bhupendra Kumar for providing the support and a stimulating academic environment essential for the research.

Finally, I am thankful to GH Raisoni College of Engineering and Management Nagpur (GHRCEMN) for offering me the opportunity to undertake this project and for supporting our academic pursuits.

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